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May Measurement Month 2022: results from the global blood pressure screening campaign

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ABSTRACT

Introduction Elevated blood pressure (BP) is the major contributor to mortality and disease burden worldwide. May Measurement Month (MMM) is a global BP screening campaign, which aims to raise awareness of BP measurement and provide evidence to inform and influence related health policy.

Methods This cross-sectional survey included individuals aged≥18 years recruited through opportunistic sampling at sites in 60 countries during MMM 2022. Each participant had three sitting BP measurements and a questionnaire was completed including demographics, comorbidities and lifestyle factors. Hypertension was defined as a systolic BP≥140 mm Hg and/or a diastolic BP≥90 mm Hg (average of the second and third readings) or taking antihypertensive medication. Multiple imputation was used to estimate BP readings where any participant's BP readings were missing. Linear mixed effects models were used to identify associations between participant characteristics and systolic or diastolic BP.

Results Of the 715 518 participants surveyed (excluding 50 200 self-measured home BP screenees recruited via the ZOE Health Study app), 257 421 (36.0%) were identified as hypertensive, of whom 57.6% were aware and 49.3% were on antihypertensive medication. Of all participants with hypertension, 26.1% were controlled to <140/90 mm Hg and 12.0% to <130/80 mm Hg. Of those taking antihypertensive medication, 52.7% were taking only one drug class, 52.9% were controlled to <140/90 mm Hg and 24.4% to 130/80 mm Hg. In total, 190 314 (26.6% of total surveyed, 73.9% of hypertensives) participants screened were found to have untreated or inadequately treated hypertension. Only 27.6% of treated hypertensive participants were taking a statin. Substantial coexistence of diabetes, overweight and hypertension was apparent among participants.

Conclusions MMM confirms a high global burden of hypertension with low rates of awareness, treatment and control. In the absence of systematic BP screening in many countries, the results from MMM underscore the continued need for BP screening to detect and thereby control raised BP.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Although raised blood pressure (BP) is the largest single contributor to the global burden of disease and mortality, awareness among those with hypertension is low, and detection, treatment and control rates of hypertension have worsened in recent years.

WHAT THIS STUDY ADDS

⇒ With its global coverage, May Measurement Month offers a unique opportunity to present the hypertension care cascade and associates of raised BP, particularly in areas of the world under-represented in epidemiological research.

⇒ Among over 750 000 opportunistically screened adults from 60 countries worldwide, almost one in five participants had never had their BP measured and a high prevalence of hypertension with low rates of awareness, treatment and control was confirmed.

⇒ Only about a quarter of those on antihypertensive medication were controlled to the currently recommended BP target of <130/80 mm Hg.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ BP measurement is critical for the diagnosis and management of raised BP.

⇒ Therefore, these findings can inform and should persuade governments and health policymakers to improve BP screening and management facilities, and thereby reduce the enormous global health burden caused by raised BP.

INTRODUCTION

Before the onset of the COVID-19 pandemic in 2019, raised blood pressure (BP) was established as the biggest single contributor to the global burden of disease and mortality.[1 2] This in part reflects the data from high-income and lower-middle-income countries, which showed that hypertension affected approximately one-third of adults worldwide and that the rates of awareness or diagnosis of

hypertension were on average less than 50% of those affected.[3 4] This is likely attributable to resource limitations for public health and health systems in these regions, as well as historic competition for resources from infectious diseases. In response to the shortfall in awareness of raised BP, and the pivotal role which diagnosis plays in determining the control rates of hypertension, the May Measurement Month (MMM) campaign was initiated in 2017 by the International Society of Hypertension.[5] Since its inception, the primary aim of MMM has been to raise awareness of the importance of BP screening at the individual and population level.[6]

Since then, in the four completed and published annual campaigns to date, almost five million adults have undergone opportunistic BP screening in over 100 countries and among those screened, over 1.1 million adults with untreated or inadequately treated hypertension have been detected.[7–10] However, despite the assumed benefits of the MMM campaigns among those screened up to 2021, the detection, treatment and control rates of hypertension among over 1.3 billion adults estimated to have raised BP worldwide, have reportedly worsened since 2019.[11 12]

This is presumably the result of the competing demands which the COVID-19 pandemic placed on healthcare professionals. Meanwhile, the World Heart Federation[13] and recent European guidelines on the management of hypertension[14] have emphasised the importance and valuable role of opportunistic screening for raised BP as central to improving the detection, and thereby management of raised BP. In keeping with these recommendations,[13 14] the MMM campaign has continued on an annual basis, with plans to expand in terms of countries involved and participants screened, as suggested by the results of the MMM22 campaign presented here compared with MMM21.[9]

MMM therefore continues to raise much needed awareness of the importance of BP measurement and in the process provides a temporary, inexpensive and pragmatic solution to the shortfall in BP screening programmes available in most countries of the world. Ultimately, the data generated are intended to inform and persuade governments and health policymakers to improve BP screening and management facilities and thereby reduce the enormous global health burden caused by raised BP. Given the impact of the pandemic on healthcare systems worldwide, it is important to understand the determinants of BP control, including the effects of infection and chronic complications of COVID-19, such as long COVID. The findings of MMM22 therefore incorporate data on several new variables, including duration of COVID-19 symptoms, in addition to data on arrhythmias and use of associated medications, and brings focus on the low rates of controlled BP achieved around the world using the more contemporary target of 130/80 mm Hg for BP control recommended in the latest guidelines.[14 15] To address the increased focus on home BP monitoring in recent guidelines, for the first time, MMM has collaborated with the ZOE Health Study app to include self-measured home BPs, providing the opportunity to compare home BP monitoring to opportunistically screened BP.

METHODS

Study design

MMM is a cross-sectional survey following a single protocol and conducted at screening sites across the world. Adult patients (≥18 years) are recruited opportunistically using convenience sampling. Screening was conducted from April to August 2022. National lead investigators were appointed in each collaborating country via MMM's network of investigators and through international and national hypertension and cardiovascular disease societies. They were responsible for establishing sites in a range of locations across their country and for obtaining ethical approval if required.

Volunteers were recruited and trained in BP measurement using materials available via the MMM website (https://maymeasure.org). As in previous MMM campaigns, OMRON donated additional BP devices where required, but any validated device, less than 5 years old, could be used. Three-quarters (75.6%) of participants were documented as having had their BP measured using an OMRON device. The campaign was promoted centrally through social media, trade press and newsletters, and locally, via television, online news segments and local press. Adult participants who were able to give informed consent to participate were recruited and three seated BP measurements were taken at 1 min intervals after 5 min rest. The mean of the second and third BP readings was used in analyses. A questionnaire collected anonymised information on demographics, medical history and lifestyle factors (see online supplemental appendix page 11). Weight was either measured, or, if equipment was not available, self-reported.

Sites were encouraged to enter data via the MMM mobile app, available in eight languages and developed for use in the field without internet connectivity. Alternatively, data could be collected on Microsoft Excel templates. In addition to the routine MMM data collection, self-measured home BPs were collated from ZOE Health Study app users in the UK and provided in an aggregated form (see online supplemental appendix for details).

Raised BP was defined as a systolic BP≥140 mm Hg and/or diastolic≥90 mm Hg based on the average of the second and third BP readings, and normal BP was defined as having a systolic BP<140 mm Hg and diastolic BP<90 mm Hg whilst on no antihypertensive medication. For ZOE participants, a lower threshold for raised BP of ≥135/85 mm Hg was used, as recommended for home BP readings,[14–16] and normal BP was defined as having a systolic BP<135 mm Hg and diastolic<85 mm Hg.

Hypertension was defined as having raised BP or being on antihypertensive medication. Hypertension awareness

was defined as having a previous diagnosis of hypertension or being on antihypertensive medication. Controlled BP was defined as taking antihypertensive medication and having normal BP. Control was also evaluated using the more contemporary target of<130/80 mm Hg currently recommended in many guidelines.[14–16]

Participants with raised BP were provided with a 'Ten Top Tips' summary of lifestyle and dietary advice for lowering BP and further advice for onward referral to healthcare services dependent on need and locally available services (see online supplemental appendix page 12).

Data handling and statistical analyses

Data were cleaned centrally according to prespecified cleaning criteria (online supplemental appendix page 13). Participants aged 18 years and above with at least one valid systolic and diastolic BP reading were retained. After cleaning, countries with fewer than ten participants were excluded.

Data were managed using R V.4.3.0[17] and analysed using Stata V.18.0.[18] Geographic regions were defined using the United Nations classification[19] with minor modifications to match previous MMM regional analyses and create groupings of comparable size. Countries were grouped into income categories based on World Bank 2021 estimates of gross national income per capita.[20] WHO-derived single-age world-standard population was used for age–sex standardisation, according to the Surveillance, Epidemiology, and End Results group, and assuming an equal female-to-male ratio.[21]

For participants missing one or two BP measurements, multiple imputation using chained equations was used to estimate the missing mean reading (for details, see online supplemental appendix pages 15 and 16). Two imputation models were created. The first, 'complete', model was run only for men or women with complete information on age, ethnicity and use of antihypertensive medication. The second, 'partial', model was run on all participants and computed missing systolic and diastolic BP values using available BP readings only. For each model, 15 imputations were created corresponding approximately to the percentage of missing data in the mean BP readings and aiming for a Monte Carlo error of the estimates at under 10%.[22] The imputed BP values of the two models were combined such that only where the complete model could not impute values for an individual were imputed values from the partial model used. Please see online supplemental appendix tables S1–3 for more detail.

Analysis of measures of association used only those male or female individuals with complete data on age and use of antihypertensive medication. Linear mixed effects models were run separately for systolic and diastolic BP, assuming a random intercept model to account for country-level clustering effects. Age, sex, an interaction between age and sex and antihypertensive medication use were included as a priori predictors, given the known strong effects of these variables on BP. Age was included into models as a restricted cubic spline with five knots to allow for flexibility in modelling its relationship with BP.

As individual readings were not available for ZOE participants, ZOE data were neither included in the imputations of missing BP readings nor their analyses. Counts of ZOE participants were combined with imputed counts to summarise the overall number of hypertensive participants surveyed. ZOE data are included in the data referred to in table 1 and certain supplementary tables; otherwise, unless explicitly specified, results only refer to the 715 518 non-ZOE MMM participants.

Patient and public involvement

Those measuring BPs were usually volunteers from the general public who are trained in BP measurement coordinated by MMM national investigators. The questionnaire is developed in collaboration with national

Table 1 Worldwide and regional distributions of age, sex and antihypertensive medication

Region	Participants (n)*	Women		Men		On antihypertensive treatment
		Total	Mean age, years	Total	Mean age, years	
Americas	200 923 (26.2%)	115 971 (57.7%)	51.3	84 223 (41.9%)	52.9	52 437 (26.1%)
East Asia	190 823 (24.9%)	94 967 (49.8%)	45.6	95 789 (50.1%)	46.4	11 889 (6.2%)
Europe	114 456 (14.9%)	70 726 (61.8%)	59.1	43 447 (38.0%)	60.5	38 072 (33.3%)
Northern Africa and Middle East	23 075 (3.0%)	13 142 (57.0%)	37.8	9925 (43.0%)	42.2	3474 (15.1%)
South Asia	91 475 (11.9%)	42 064 (46.0%)	42.5	49 069 (53.6%)	43.9	13 399 (14.6%)
Southeast Asia and Australasia	66 575 (8.7%)	39 633 (59.5%)	47.7	26 872 (40.4%)	47.6	18 273 (27.4%)
Sub-Saharan Africa	78 391 (10.2%)	42 853 (54.7%)	41.9	35 023 (44.7%)	41.9	7617 (9.7%)
Worldwide	765 718 (100%)	419 356 (54.8%)	48.7	344 348 (45.0%)	48.9	145 161 (19.0%)

*410 participants with sex recorded as 'other' and 1604 participants with unknown sex are not shown in the table due to small numbers.

investigators, based on feedback received from participants in previous years.

RESULTS

Data were collected from a total of 765 718 participants from 60 countries. Of these, 113 242 (14.8%) were submitted via the MMM app and 50 200 (6.6%) via the ZOE app.

Participant summary

Of the 60 participating countries, 38 were upper-middle-income or high-income countries, representing 69.6% of participants (online supplemental appendix table S4). A complete description of survey participants can be found in online supplemental appendix table S5. The mean age of participants was 48.8 (SD 17.6) years, with more women than men (54.8% vs 45.0%) (table 1). The most commonly reported ethnicity was East/Southeast Asian (33.5%).

Most participants were screened in the Americas (26.2%), East Asia (24.9%) or Europe (15.0%). Distributions of age, sex and medication use differed by region (table 1). The region with the highest mean age was Europe (59.6 years), while the lowest mean age was Sub-Saharan Africa (41.9 years). The region with the lowest percentage of female participants was South Asia (46.0%), while 61.8% of participants from Europe were women. One-third of European participants were using antihypertensive medication compared with only 6.2% of East Asian participants.

Half (49.9%) of participants had had their BP measured in the past year, while 18.5% had never had their BP measured. Nearly half (45.8%) of participants were screened while visiting a hospital, clinic or pharmacy, and a total of 70.6% of participants were screened using an OMRON BP device. Three-quarters (75.3%) had never participated in a previous MMM campaign.

A total of 640 987 (83.7%) of participants had three BP readings taken (online supplemental appendix table S1). Mean systolic and diastolic BP decreased across subsequent readings from an average first reading of 126.4/80.7 mm Hg to an average of 123.6/78.9 mm Hg for the third reading. Consequently, the estimates of the percentage with hypertension decreased from 39.6% (first reading) to 35.7% (third reading) (p<0.0001) (online supplemental appendix table S2). In linear mixed models of participants not taking antihypertensive medication, mean systolic and diastolic BP was higher in men than women until the age of 70 and 80 years, respectively, and thereafter, BP was similar between the two sexes (online supplemental appendix figure S1).

Hypertension and awareness, treatment and control

After imputation of missing BP readings, of 715 518 main participants, 257 421 (36.0%) participants had hypertension. Of those with hypertension, 148 438 (57.6%) were aware they had hypertension, 126 966 (49.3%) were taking antihypertensive medication, 67 207 (26.1%) were controlled to <140/90 mm Hg and 12.0% to a stricter target of <130/80 mm Hg. Of the 126 966 participants taking antihypertensive medication, 52.9% were controlled to <140/90 mm Hg and 24.4% to <130/80 mm Hg. In total, 190 314 participants (26.6% of all those surveyed and 73.9% of those with hypertension) had untreated or inadequately treated hypertension. In a sensitivity analysis, similar estimates of the proportion with hypertension were obtained by the complete case (35.9%), partial (36.1%) and full (36.0%) imputation models (online supplemental appendix table S3). Of those that had never had a BP measured before, 31 653 (22.4%) had raised BP. Corresponding estimates of the parameters of the hypertension care cascade including ZOE app users can be found in online supplemental appendix table S6.

Estimates of the proportion with hypertension increased with age in both male and female participants (online supplemental appendix table S7). Hypertension was more prevalent in men than women across all age groups.

Proportions of those with hypertension and rates of awareness, treatment and control among them varied greatly by region (table 2). The percentage of participants with hypertension was highest in Europe at 48.9% and lowest in East Asia (26.6%). Awareness and treatment rates among hypertensives were both lowest in East Asia (24.1 and 23.4%, respectively). Control was lowest in East Asia where 13.6% of hypertensives were controlled to <140/90 mm Hg and 6.8% to <130/80 mm Hg.

Due to differences in the age and sex distributions of each region (table 1), age–sex standardised estimates of hypertension were calculated. After age–sex standardisation, differences in the percentages with hypertension between regions were attenuated (online supplemental appendix table S9) with hypertension rates in the Americas, Southeast Asia and Australasia, and Europe decreasing by more than 5% in absolute terms. See online supplemental appendix tables S10 and S11 for further detail on BP control to <130/80 mm Hg, including age–sex standardised estimates.

Medication

Of the 715 518 main MMM participants, 126 966 (17.7%) were on antihypertensive medication. Of these, 66 939 (52.7%) reported taking a single class of drugs, 43 193 (34.0%) were on two and 15 975 (12.6%) were on three or more.

Of the 100 080 participants who reported the regularity of taking antihypertensive medication, 16 994 (14.5%) stated they did not take their medication regularly. Of those not taking medication regularly, reasons included taking them only 'when needed' (42.6%), issues with medication availability (15.5%), forgetfulness (15.0%), expense (14.1%), a preference for alternative medications (5.8%) and side effects (3.4%). Of those who reported taking their antihypertensive medication regularly, 54.3% (average BP 135.9/82.5 mm Hg)

Table 2 Worldwide and regional estimates of percentage with hypertension, awareness, on treatment and controlled of 715 518 participants*

Region	Number with hypertension	Percentage of total participants with hypertension (%)	Percentage of hypertensives aware (%)	Percentage of hypertensives on medication (%)	Percentage of those on medication with BP <140/90 mm Hg (%)	Percentage of those on medication with BP<130/80 mm Hg (%)	Percentage of all hypertensives with BP<140/90 mm Hg (%)	Percentage of all hypertensives with BP<130/80 mm Hg (%)
Americas	86 632	43.1	75.5	60.5	60.3	28.6	36.5	17.3
East Asia	50 830	26.6	24.1	23.4	58.1	29.2	13.6	6.8
Europe (excluding ZOE)	31 422	48.9	70.8	63.3	48.9	21.1	30.9	13.3
Northern Africa and Middle East	7277	31.5	51.2	47.7	49.0	20.7	23.4	9.9
Southeast Asia and Australasia	27 965	42.0	72.1	65.3	34.2	13.5	22.4	8.8
South Asia	29 426	32.2	52.8	45.5	55.7	25.7	25.4	11.7
Sub-Saharan Africa	23 969	30.6	37.6	31.8	46.5	21.8	14.8	6.9
Worldwide	257 421	36.0	57.6	49.3	52.9	24.4	26.1	12.0

*Associated 95% CIs in online supplemental appendix table S8. Results for worldwide totals including participants using the ZOE app are included in online supplemental appendix table S6.

had controlled BP compared with 42.5% (average BP 140.1/85.5 mm Hg) of those not taking their medication regularly.

Of those on antihypertensive medication, 52.3% paid nothing for their consultations and 38.2% paid nothing for their medication. Overall, 36.7% of participants on antihypertensive medication paid for neither their consultations nor medication, of whom 54.2% were controlled (average BP 136.2/82.5 mm Hg) compared with 51.9% (average BP 136.6/83.2 mm Hg) of those who reported paying at least something.

Of those on antihypertensive medication, 35 032 (27.6%) reported taking a statin. Of the 19 208 (2.7%) participants with a history of stroke or myocardial infarction, 8523 (44.4%) reported they were taking a statin, 8558 (44.6%) were on aspirin and 7855 (59.1%) were not taking antihypertensive medication. Of the 28 657 participants with a history of atrial fibrillation or irregular heartbeat, 10.5% reported taking warfarin or another anticoagulant medication.

COVID-19

Information on COVID-19 test, vaccination and symptom history were collected from 715 518 MMM participants. A total of 105 930 (14.8%) participants reported a previous positive test for COVID-19, of whom 64.6% had a positive test in the past year, while 29.4% received a positive test more than 12 months ago. Of 97 710 respondents who reported a positive test and on the duration of their symptoms, 80.3% stated their symptoms lasted 3 months or less, 9.8% that their symptoms lasted three to 6 months and a further 9.8% stated their symptoms lasted for more than 6 months. About three-quarters of participants (n=552 350) stated they had received a COVID-19 vaccination and 336 284 (47.0%) reported having received three doses.

Small but statistically significant differences in adjusted average BP by the COVID-19 risk factors were apparent (figure 1). Any previous COVID-19 vaccination was associated with slightly lower systolic and diastolic BP. Having a previous positive COVID-19 test was associated with higher diastolic, but not systolic BP, compared with participants with no previous positive test. Of those who had a previous positive test, having COVID-19 symptoms lasting greater than 3 months was associated with higher average systolic and diastolic BP.

ZOE

A total of 50 200 (6.6%) respondents from the UK measured their own BPs at home and were included via the ZOE application. Compared with all other European MMM participants (n=64 256), ZOE participants were older (78.3 vs 40.5% over 60 years old) and more frequently women (65.8 vs 58.7%). ZOE participants had a slightly higher prevalence of hypertension (49.7 vs 48.9%) but, among hypertensive participants, a greater proportion of ZOE participants were treated (67.5 vs 63.3%), aware (73.8 vs 70.8%) and controlled (37.5 vs

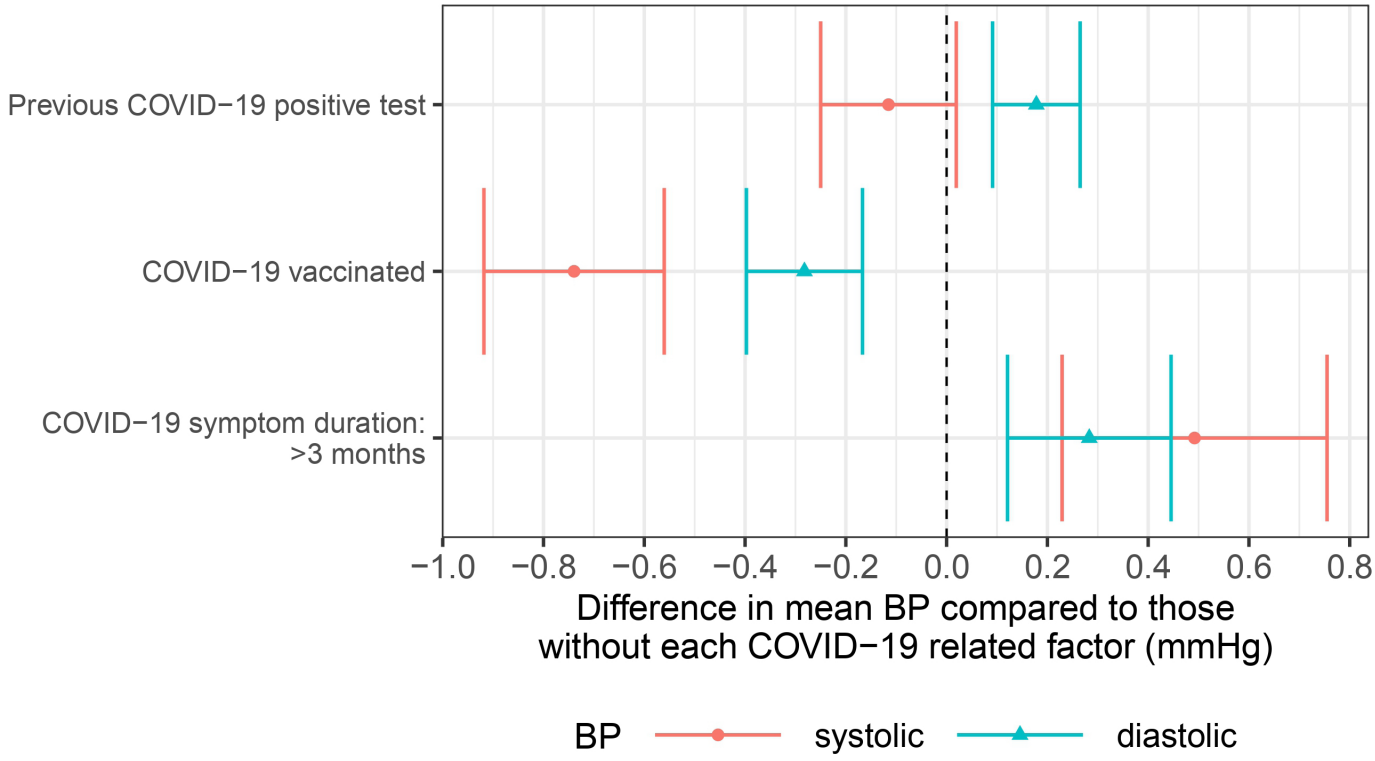

Figure 1 Difference in mean blood pressure (BP) in those with each COVID-19-related factor compared with those without. Estimates are derived from linear mixed models adjusted for age, sex and antihypertensive medication use. Error bars represent 95% CIs. Analysis of COVID-19 symptom duration was done for those with a previous positive COVID-19 test only. Corresponding estimates can be found in online supplemental appendix table S18.

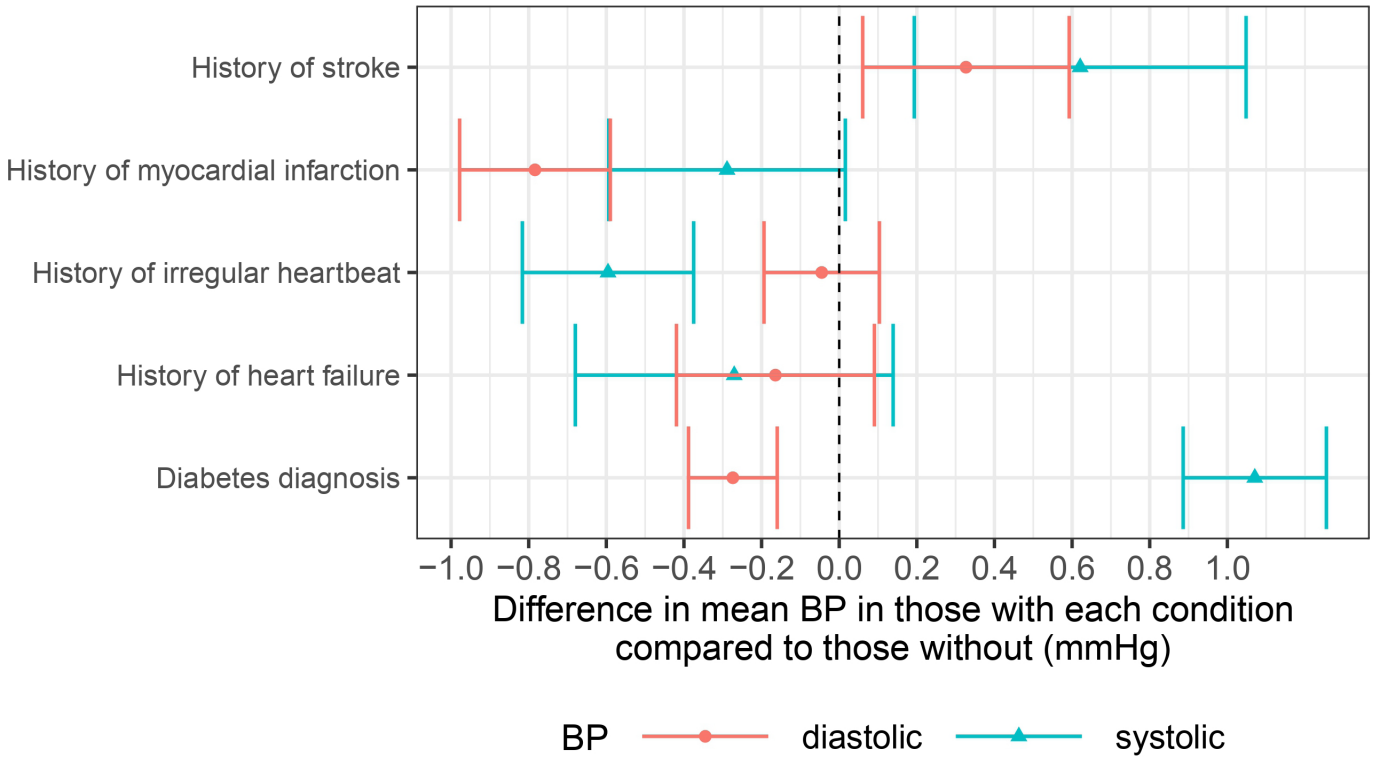

Figure 2 Difference in mean blood pressure (BP) in those with each condition compared with those without. Estimates are derived from linear mixed models adjusted for age, sex and antihypertensive medication use. Error bars represent 95% CIs. Corresponding estimates can be found in online supplemental appendix table S13.

30.9%) compared with other European participants. A full description of the estimates of the parameters of the hypertension care cascade for European MMM participants including ZOE app users can be found in online supplemental apendix table S6.

Associations

Small differences in BP were observed between those with a history of certain cardiovascular or metabolic conditions and those without (figure 2). Participants with a diagnosed history of irregular heartbeat had significantly lower systolic but not diastolic BP, those with diabetes had significantly higher systolic but significantly lower diastolic BP, those with a history of stroke had significantly higher systolic and diastolic BP and those with a history of myocardial infarction had lower diastolic BP. No significant difference in BP between those with and without a diagnosis of heart failure was observed.

Of 257 521 participants with hypertension, one-third (33.8%) had either diabetes or were in the top weight quartile (≥78 kg) (online supplemental appendix figure S2). Half of participants (50.8%) in the top quartile of weight were hypertensive. Over half (65.9%) of the 47 914 participants with diabetes were hypertensive, 31.1% of whom were also in the top quartile of weight.

Average diastolic BP showed a continuous graded increase with increasing pulse rate values (figure 3). In contrast, systolic BP decreased as average pulse rate rose from <60 to 70 beats per minute (BPM) but thereafter only increased with pulse rates>90 BPM (figure 3). This relationship was not affected by stratification by antihypertensive medication use (online supplemental appendix figure S3).

Associations between other participant characteristics and average systolic or diastolic BP were in line with previously reported findings from other MMM campaigns (online supplemental appendix tables S12–19).[7 8 10]

DISCUSSION

In MMM 2022, over 750 000 adults from 60 countries were included and over 250 000 participants (36.9%) were classified as hypertensive, of whom 40% were unaware, almost half were untreated and only about one in seven were controlled to currently recommended targets. Rates of awareness, treatment and control were worse in the African and Asian regions than in Europe and the Americas. These regional differences were partly explained by variation in age and sex distributions (online supplemental appendix tables S9 and S11). However, regional differences in estimates of hypertension and its management persisted after age–sex standardisation. This may reflect real underlying differences between populations but could be attributable to variation in recruitment methods. Although we cannot directly quantify whether MMM raises awareness at a population level where screening took place, the individual impact is evident from the 200 000 people who were found to have either untreated, or inadequately treated hypertension and

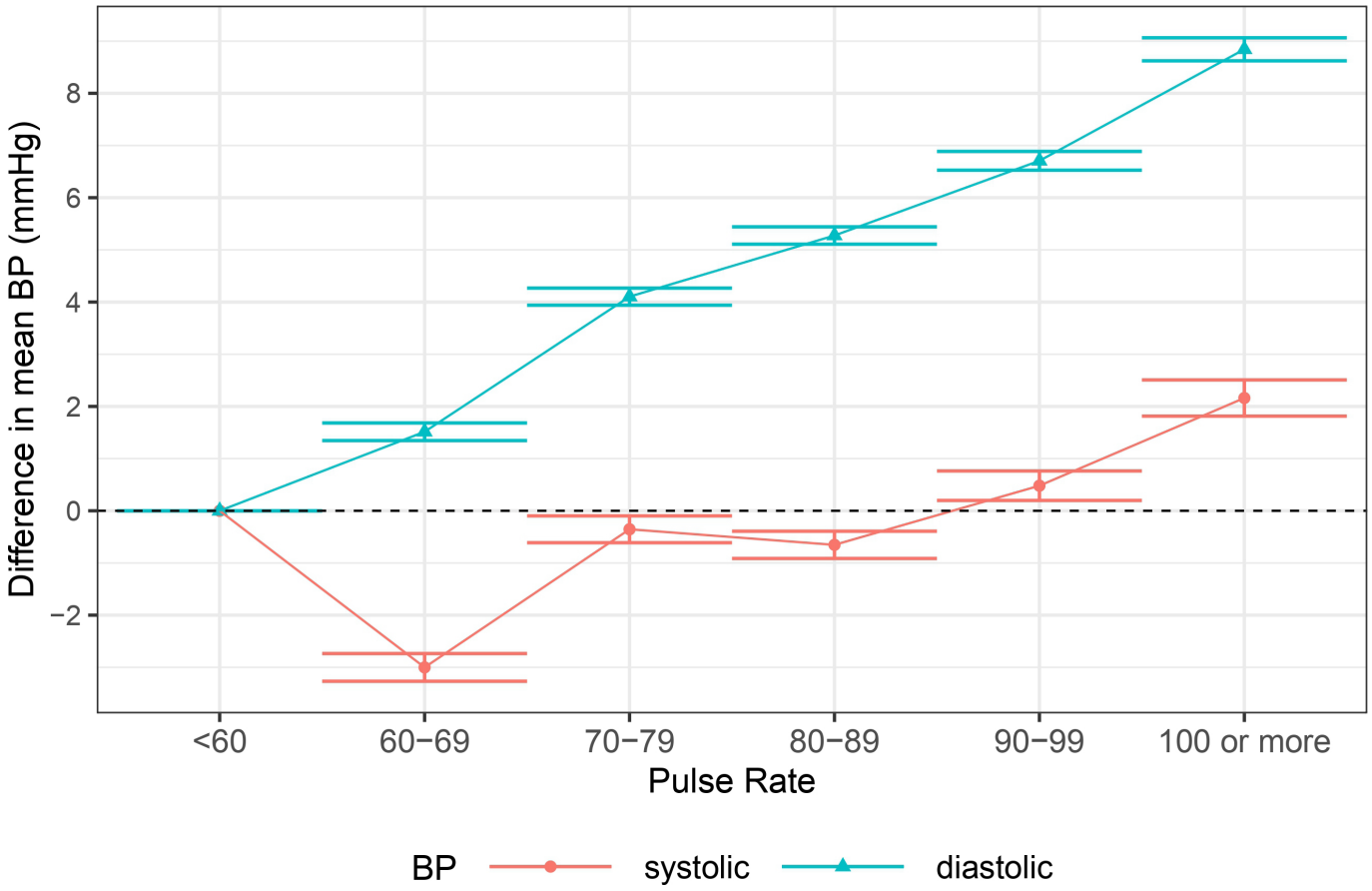

Figure 3 Difference in mean blood pressure (BP) across pulse rate categories compared with a pulse rate of 60 beats per minute. Estimates are derived from linear mixed models adjusted for age, sex and antihypertensive medication use. Error bars represent 95% CIs. Corresponding estimates can be found in online supplemental appendix table S19.

were provided with lifestyle advice and directed to further follow-up as required.

In those with treated hypertension, our findings highlight that BP control rates remain poor globally. Using a conservative target of 140/90 mm Hg, 46% had uncontrolled BP, rising to 72% using the target of 130/80 mm Hg recommended for most patients by several recent guidelines.[14–16] Reasons for poor control rates are complex and multifactorial, but our finding that half of those on antihypertensive medication were taking only a single drug class is likely to be a significant factor and contradicts recommendations in all contemporary guidelines.[14] Furthermore, this suggests that promoting more frequent initiation of treatment with two-drug combinations, and greater use of single-pill combinations including two or more drug classes might represent an effective approach for improving BP control.[14–16] Considering broader cardiovascular prevention among patients with hypertension, only 27.6% were taking a statin, considerably less than recommended by current guidelines.

For the first time, MMM22 included a subset of participants who contributed with self-measured home BPs, collected via the ZOE Health Study app. These participants tended to be older, with slightly higher rates of hypertension, but better awareness, treatment and control than other European participants. This is unsurprising given these digitally enabled and health-conscious ZOE participants were self-selected users of a health app who may have greater access or engagement with effective BP management strategies. Including those collected via the ZOE app, treatment and control rates were similar to previous years, but when excluding those from ZOE, rates were slightly lower (online supplemental appendix table S20).

The screening strategy used in MMM is, by design, opportunistic and intended to screen any consenting participants, in contrast to national prevalence studies which use representative sampling. Nevertheless, despite the inclusion of non-representative samples screened in different countries and across the years, the MMM results have been remarkably consistent in terms of global proportions with hypertension and in the rates of awareness, treatment, and control. Although we cannot directly interpret trends over time due to the convenience sampling, the slightly higher percentage of participants with hypertension in 2022 compared with previous years (online supplemental appendix table S20) may be partially explained by the relatively higher mean age. Furthermore, existing evidence suggests that the COVID-19 pandemic has had a detrimental impact on BP diagnosis, treatment initiation and follow-up rates.[11 12] In conjunction with our results, these findings suggest that

lower treatment and control rates in MMM22 may represent a persisting negative impact from the pandemic on healthcare access for diagnosis, initiation of medication, BP control and follow-up.

With its global coverage, particularly in areas of the world under-represented in epidemiological research, MMM offers a unique opportunity to examine the determinants of raised BP levels. Although the primary aim of MMM has remained unchanged, we have expanded our scope to recruit a wider range of participants and use the data collected to provide a robust research platform to allow the evaluation of novel aspects of health. Each year, the questionnaire is updated to provide new insights into risk factors, comorbidities and management. Previous analyses of MMM data, for example, have highlighted poor BP control in stroke survivors,[23] associations with specific multimorbidity patterns[24] and the determinants of the variation between first, second and third BP readings.[25 26] In MMM22, we found small differences in average BP levels in people with comorbidities, with slightly higher systolic and diastolic BPs on average in people with a previous stroke, consistent with previous findings.[23] We found a clear direct relationship between heart rate and diastolic BP, while systolic BP appears to have a U-shaped relationship with increasing heart rate (figure 3), a finding that surprisingly was not dependent on antihypertensive medication use. Although as yet unexplained, we found the same pattern in previous global MMM data.[10]

In MMM22, information was collected on the persistence of COVID-19 symptoms, finding that 18.2% of participants had symptoms ongoing over 3 months from onset, consistent with a diagnosis of long COVID.[27] Those with a history of long COVID had a small, but statistically significant increase in both systolic and diastolic BP (figure 2), but it was not possible to distinguish between current or resolved symptoms at the time of BP measurement. Evidence suggests that hypertension may be both a risk factor for long COVID, and a downstream complication of infection, which may explain this association, but there is a need for further research to better understand the risk of long COVID on longer term cardiovascular health.[28]

Strengths and limitations

Despite the impact of the COVID-19 pandemic resulting in a reduced number of countries compared with prepandemic years, the MMM campaign has regained its momentum in 2022, with 60 countries screening over three-quarters of a million people. The 2022 questionnaire was updated to capture new aspects of health, providing novel insight into factors relevant to BP and its management, including long COVID and arrhythmia management. Also, for the first time, we present regional control rates using the more contemporary BP target of<130/80 mm Hg, reflecting latest guidelines.[14 15]

Given the convenience sampling, estimates from MMM at a global, regional or national level should not be interpreted as representative estimates of general population prevalence, treatment and control. Likewise, comparisons between regions and countries should be interpreted cautiously, given likely differences in the population structure and sampling techniques. Despite these limitations, findings from MMM represent real world results from opportunistic screening programmes, which are more easily implementable, particularly in those settings lacking in robust health data infrastructures, where more systematic screening may currently be out of reach. Furthermore, despite the lack of representative sampling, inferences from associations within the sample are internally valid[29] and a strength of the data derives from its large and diverse mix of participants across many countries. Consequently, clear, strong associations have been shown between various measures of MMM BP management and rates of premature stroke mortality at a national level.[23]

A further limitation is that the design of MMM is cross-sectional, without follow-up data to evaluate the impact of screening. Participants with raised BP are provided with lifestyle advice and advice on further medical review dependent on local resources, but we are unable to assess whether participants received further follow-up, nor the longer-term impact on their BP. Despite this, evidence from a study of community screening in China, which screened individuals and provided advice in a similar manner to MMM, found a reduction in systolic BP that persisted at 2 years.[30] In future MMM campaigns, we plan to incorporate follow-up of a subset of participants to better understand the long-term impact.

CONCLUSION

Based on screening over three-quarters of a million people in 60 countries, the results of MMM22 underline the persistent global challenge relating to low rates of awareness, treatment and control of hypertension worldwide, with 200 000 of those screened found to have untreated, or inadequately treated hypertension. Given that hypertension remains the single biggest contributor to mortality worldwide, in the context of a likely worsening of diagnosis, treatment and control rates during and after the pandemic, the case for screening is stronger than ever. Without the critical step of BP measurement, which is required for the diagnosis of raised BP, improvement of BP control cannot be realised. Although systematic screening is optimal and much needed, it remains unattainable in many regions. In the meantime, MMM offers a practical and low-cost route to improving awareness and detection of raised BP at a global level, which we aim to continue annually.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. Where a country requires ethical approval to carry out the MMM campaign in a given country, the MMM country lead is responsible for completing the relevant paperwork and submission to secure ethical approval, and all associated costs are covered by MMM core funding. Once approval has been secured, copies of the approval documents/letter are sent to the central MMM global team for reference. At the time of each new campaign briefing the MMM global team ensures that each country lead understands the importance of securing ethical approval for their country, if required, to ensure that any data collected can be used and referenced for global HTN awareness and rates once the campaign has concluded. In most countries, ethical approval is not required as MMM does not collect identifiable information for each participant. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available on reasonable request. The data used in this study are available for research purposes on approval from the May Measurement Month Management Board (https://maymeasure.org/about/). For further information or to request access, please contact the corresponding authors TB or NP.

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